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Applicant (71) COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION.

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Related Art (56)

260,092(10,441/61)	40.7
288,664(51,009/64)	40.7; 60.2; 60.3
238,942(54,212/59)	40.7.

The following statement is a full description of this invention, including the best method of performing it known to us :

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W. G. Murray, Government Printer, Canberra

This invention relates to the formation of twisted thread assemblies and is applicable particularly, but not exclusively, to the preparation of yarn comprised of staple fibres, for example wool fibres.

The complete specification of our Australian Patent No. 260,092 discloses the preparation of a yarn by twisting a strand so that it has repeated along its length alternating zones of opposite twist and converging that twisted strand with another strand and allowing it to twist around that other strand. Both of the strands, or all of them if there be more than two, may be intermittently twisted and converged with the regions of twist in the strands suitably phased so that, when the strands commence to untwist, they twist around each other and this plying of the strands restrains the twist in each individual strand to result in a self-stabilized plied assembly. Such an assembly will hereinafter for the sake of convenience be called "self-twist" thread or, where appropriate, more specifically "self-twist yarn".

A self-twist yarn can be produced at much faster rates than conventional plied yarns. However, it has been found that simple self-twist yarns are not entirely satisfactory in all weaving and knitting applications. The present invention is a development of the invention disclosed in our Australian Patent No. 260.092 and, as will be explained in detail hereinafter, it enables the formation of a yarn particularly suitable for weaving or alternatively a yarn which can be knitted most successfully and both types of yarn can be produced at the same rate as simple self-twist yarns.

According to the invention there is provided a process for forming a stable twisted thread assembly, comprising individually twisting at least one strand of a group of strands so that each twisted strand has repeated along its length successive zones of opposite twist separated by strand twist change-over regions at which there is no twist, converging the strands of the group so that they twist around one another such as to form a stable first thread having successive zones of opposite plying twist separated by plying twist change-over regions at which there is no plying twist, twisting said first thread to superimpose alternately opposite twist in successive zones along its length which latter zones are separated by superimposed twist change-over regions of no superimposed twist, and converging the twisted first thread with a second thread so that the two threads twist around one another to form a stable twisted assembly.

The second thread may be a single strand or alternatively it may be formed by individually twisting at least one strand of a further group of strands so that each twisted strand of the further group has repeated along its length successive zones of opposite twist separated by strand twist change-over regions at which there is no twist and then converging the strands of the further group so that they twist around one another such as to form said second thread as a stable assembly having alternating zones of plying twist separated by plying twist change-over regions at which there is no plying twist.

Before the second thread is converged with the first thread, it may be twisted such as to impart alternately

opposite twist to successive zones along its length which latter zones are separated by change-over regions of no imparted twist.

The invention also provides a yarn comprised of a stable twsited thread assembly formed by the above-defined process.

The invention further extends to the provision of apparatus for producing a stable twisted thread assebmly, comprising first twisting means simultaneously to impart successive zones of opposite strand twist to each strand of a group of strands, first converging means adjacent the first twisting means to converg the strands of the group to form a first thread, second twisting means to superimpose successive zones of opposite twist upon the first thread and second converging means adjacent the second twisting means to converg the first thread with a second thread.

In order that the invention may be more fully explained, one form of apparatus and its use in the production of warp yarns in weaving and also knitting yarns will now be described in detail with reference to the accompanying drawings in which:-

Figure 1 is a somewhat diagrammatic perspective view of one form of apparatus constructed in accordance with the invention;

Figure 2 is a front elevation of the apparatus illustrated in Figure 1;

Figure 3 is a diagrammatic plan view of the apparatus;

Figure 4 is a diagrammatic representation of a two-strand self-twist thread produced at an intermediate stage in the production of a yarn by means of the apparatus;

Figure 5 is a diagrammatic representation of one four-strand yarn which can be produced by the apparatus;

Figure 6 is a diagrammatic plan view of part of the apparatus and shows how the path of a thread passing through it can be altered so as to change the twist distribution in the final yarn; and

Figure 7 is a diagrammatic plan view of part of the apparatus showing how it can be operated to produce a three-strand yarn.

The illustrated apparatus comprises a conventional drafting unit 11 and two pairs of oscillating twisting rollers 12, 13 of the type illustrated in Figures 1 to 5 of our Australian Patent Specification No. 288,664. The roller of each pair 12, 13 are rubber covered and arranged so that they are just touching or with a small gap between them. These rollers are driven so that they reciprocate in opposite phase and rotate in opposite directions so that their adjacent surfaces move in the direction in which strands are fed forwardly by the drafting mechanism at substantially the same speed. The two roller assemblies are identical, in each case the rollers being mounted on a pair of shafts 14, 15 which are rotated at constant speed in opposite directions through a gear drive 10 from an input belt drive 14. In order to allow them to rotate with the shafts and at the same time to be reciprocated, the rollers are keyed to the shafts by feature keys which are free to slide in along keyways so as to allow relative sliding movement between the rollers and the shafts. The rollers of each pair are engaged by a pair of yokes 17, 18

in such a way that relative rotation between the roller and the yoke can occur but no relative translation is permitted. These yokes are connected by means of belts, pins, chains or the like 19, 20 to wheels 21, 22. The wheels 21 of the two oscillating roller assemblies are connected to a common drive shaft 16 by means of a pair of cranks 23 and connecting rods 24, shaft 16, which is rotated by a belt drive 25, is split at a position between cranks 23 and the two shaft portions thus formed are releasably coupled by means of a dual-sprocket and duplex-chain coupling 30 in order to allow the positions of the two connecting rods 24 to be adjusted relative to one another. The yokes of the two oscillating roller pair assemblies are thus caused to reciprocate on their guides 26, 27 and thereby to reciprocate the rollers as they are simultaneously rotated by gear drives 10. The coupling of the two roller mechanisms together by shaft 16 causes the oscillatory movements of the two roller pairs to maintain a required phase relationship to each other. This phase relationship will be explained hereinafter.

Figures 3 to 5 illustrate the manner in which the apparatus may be employed to produce a four-strand yarn which is particularly suitable for weaving. Four spaced strands 31 are passed from drafting unit 11 through the first pair of twisting rollers 12. These rollers impart to each thread 31 alternating zones of opposite twist, which zones are of equal length and are separated by twist change-over regions at which there is no twist. On leaving rollers 12, the strands are immediately converged in two pairs by means of a pair of convergence guides 32 to form

two intermediate self-twist yarns 33 each consisting of two of the strands 31 plied together with their twist zones in phase. The configuration of a self-twist yarn produced merely by converging a pair of strands having the twist distribution of strands 31 and with their twist zones in phase is illustrated in Figure 4. The mechanism of the self-twisting is fully described in the complete specification of Australian Patent No. 260,092 and the yarn of Figure 4 is identical to the one illustrated in Figure 11a of that specification. In present Figure 4, the symbol is used to indicate regions in the strands in which there is no strand twist and the symbol $\triangle$ is used to indicate regions in the yarn in which there is no plying twist, regions and $\triangle$ being substantially coincident. In the zones between these regions in which the strands have individual S-twist the yarn has plying Z-twist and in the zones in which the strands have individual Z-twist the yarn has plying S-twist. Intermediate yarns 33 would have the configuration illustrated in Figure 4 but for the action of the second pair of twisting rollers 13. However, these intermediate yarns pass through rollers 13 which superimpose alternating zones of opposite twist upon them. The action of rollers 13 alters the configuration of yarns 33 immediately they are formed. However, the resultant configuration and twist distribution of each of the two yarns leaving twisting rollers 13 is that of a yarn as illustrated in Figure 4 which has alternating zones of opposite twist superimposed on it.

The superimposed twist distribution imparted by rollers 13 is similar to the twist distribution given to

the strands 31 by the first set of twisting rollers 12 but the two sets of rollers 12, 13 are so spaced from one another and their oscillating motions so phased with respect to one another that the change-over regions of superimposed twist are displaced from the twist change-over regions , △ .

On leaving the second pair of twisting rollers 13, the two yarns having the superimposed further twist are immediately converged by means of a convergence guide 34 and self-twisted together to form a stable four-strand yarn 35 which is wound onto a take-up package 36.

Because a self-twist yarn of the configuration illustrated in Figure 4 is stable (i.e. has complete torque balance), the torque distribution of each of the pair of yarns leaving twisting rollers 13 is that of a strand having the superimposed twist distribution imparted by rollers 13. However, the superimposition of the further twist on the self-twist yarn 33 causes the actual plying twist in some parts of the yarn to be diminished and in other parts to be reinforced so that the regions △ of no plying twist are displaced. The zones of no strand twist are not displaced appreciably by the twist imparted by rollers 13.

The oscillatory motion of rollers 13 is so phased with respect to that of rollers 12 that the final yarn 35 has the configuration depicted diagrammatically in Figure 5. In this figure, the individual strands of only one of the intermediate yarns 33 are indicated, the second intermediate yarn being shown in outline only. The two individual strands which are illustrated bear shading lines to indicate their strand twist distributions. The strand twist distributions

of all four-strands are identical. The regions of zero plying twist between the intermediate yarns 33 are indicated by the symbol $\ominus$ and these regions are displaced from the regions $\triangle$ of zero plying twist within the two yarns 33 which latter regions are also displaced from regions of zero strand twist.

The yarn structure illustrated in Figure 5 is particularly applicable to warp yarns for weaving. Warp yarns should have relatively high strength and abrasion resistance to withstand the tension and rubbing to which they are subjected during weaving. Simple self-twist yarns have regions of no plying twist which have low abrasion resistance and also constitute zones of weakness in the yarn. The use of such yarns as warp yarns can therefore lead to yarn breakage problems during weaving. However, because of the displacement of the various regions of zero twist in the structure of Figure 5 it is possible to produce a wool yarn of this structure which has adequate strength and abrasion resistance for use as a warp yarn.

The free length through which the converged strands 31 travel between convergence guides 32 and the second pair of twisting rollers 13 should be such as to allow an ample distance over which the converged strands can twist around one another as is more fully described in Australian Patent No. 260,092. The free length should be at least the length of a strand twist zone. For a similar reason, the distance between the convergence guide 34 and take-up package 36 should preferably be at least the length of one zone of twist imparted by rollers 13.

The distance between the two pairs of twisting

rollers, indicated as X in Figure 3, should preferably be at least one twist cycle length. For the preparation of wool yarns the distance X is preferably in the range 12 to 40 cm, an optimum value being between 25 to 40 cm, and the stroke of each pair of twisting rollers should be in the range 2 to 7 inches.

It has been found that, when preparing wool warp yarns of the structure shown in Figure 5, optimum results are achieved if the strokes of both pairs of rollers are approximately equal and approximately 3 to $4\frac{1}{2}$ inches. The oscillation frequencies of the two pairs of rollers should be the same and are preferably chosen with respect to the speed of rotation of the rollers to give cycle lengths in the range 12 to 40 cm. More particularly it is preferred that the cycle lengths be between 20 and 25 cm.

The requirements of a knitting yarn are different from those of a warp yarn in weaving. Strength and abrasion resistance are the most important criteria for a warp yarn and since, in a woven structure the yarn is held quite firmly by the interlacing threads, residual torque in the yarn is not critical. However, a knitted fabric is formed with the yarn at one tension and the tension is then allowed to relax. The new relaxed tension requires a different twist level for torque balance and, if a simple self-twist yarn having high residual twist is used, it tends to "twist up" back to its torque equilibrium condition which causes deformation of the knitted stitches and consequent distortion of the fabric. A four-strand wool yarn produced in the manner described above to have the structure of Figure 5 will also suffer from this defect if knitted.

However, a satisfactory knitting yarn can be produced by reducing the intensity of twist imparted by the second pair of twisting rollers thereby to reduce the intensity of self-twisting between the two intermediate yarns and altering the path length of one of the intermediate yarns as shown in Figure 6 so that when the two are converged the regions of no strand twist and the regions of no plying twist Δ of one yarn are not coincident with the regions and Δ of the other yarn.

As shown in Figure 6, the length of the path followed by one of the intermediate yarns (identified as 33A), as it passes from its convergence guide 32 to the second pair of twisting rollers can be increased simply by providing two further guides 37, 38. The increased path length is such that when the yarn 33A is self-twisted with the other yarn 33B after leaving the second pair of twisting rollers, its regions , Δ are displaced by approximately one half of a cycle length from the regions , Δ in yarn 33B. Furthermore the stroke of the second pair of twisting rollers is reduced so that it is less than that of the first pair of twisting rollers. It has been found that satisfactory wool knitting yarn can be produced if the stroke of the first pair of rollers is 2 inches and the stroke of the second pair of twisting rollers is about 1 inch.

A further modification aimed at reducing the Tex (i.e. weight per unit length) of the resultant yarn is illustrated in Figure 7. The yarns produced by the arrangements shown in Figures 3 and 6 each have four-strands. The finest wool strand which can conveniently be spun without

breaking problems depends on the fineness of the wool fibres. For wool having an average fibre diameter of about 24 microns the finest practicable strand is about 15 Tex so that a four-strand yarn made from such wool must be at least 60 Tex. Finer yarns are required for weaving some types of fabric. A finer, yet weaveable, three-strand yarn can be produced by means of the arrangement shown in Figure 7 and employing a continuous filament structure (either multi-filament or mon-filament) as at least one of the strands. In this arrangement only two strands 41 are passed through the first set of twisting rollers 12 and then converged to form a self-twist intermediate yarn 43. A third strand 44 in the form of a synthetic mono-filament is fed through a guide 45 directly to the second set of twisting rollers 13. The second set of twisting rollers imparts alternating twist to mono-filament 44 and the intermediate two-strand yarn 43, and mono-filament 44 and yarn 43 are then converged by a convergence guide 46 whereupon they self-twist together to form a resultant three-strand twisted yarn 47. Strand 44 may be any synthetic monofil, for example nylon, polyamide, polypropylene, alginate or other rayon, an acrylic or polyester monofil. Each of strands 41, 42 may be wool or a synthetic monofil. For example strand 41 might be a 9 Denier nylon monofil, strand 42 a 15 Tex wool strand, and strand 44 a 9 Denier nylon monofil. This will give a resultant yarn 47 of 17 Tex which is readily weaveable. Furthermore this yarn will be 88% wool and it will have many of the physical properties of a pure wool yarn.

The use of mono-filaments is not, of course, limited to the arrangement of Figure 7. A three-strand

structure could be achieved by passing strand 44 directly to convergence guide 46 without twisting it and allowing yarn 43 to twist around it. When producing a four or more strand structure with the arrangement of Figure 3, monofilament may be used as any of the strands 31.

The twist levels and strength of the yarns according to the invention can be altered by treatment with various kinds of additives. For example, if the strands used in the preparation of a wool yarn are treated with colloidal silica, their inter-fibre friction is increased and it has been found that this will alter the twist levels in the resultant yarn and will greatly increase its strength. It has been found that wool yarns produced in accordance with this invention are particularly susceptible to such treatment. The effect of such a treatment is illustrated by Example 2 below.

The following examples show the application of the present invention to the production of weaving and knitting yarns. The yarns were produced with the arrangements shown in Figures 3, 6 and 7.

EXAMPLE 1

Material - Noble combing wool of 23 microns average fibre diameter.

Method: Twisting was accomplished with the arrangement shown in Figures 1 to 3. Each roller unit had a 3 inch stroke and imparted alternating twist of 22 cms. cycle length. (As used herein the term "cycle length" designates a length of yarn occupied by a complete cycle of S and Z twist, i.e. 2 consecutive twist zones).

The roller units were phased relative to one another

so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway between twist change-over points in the individual strands produced by the first set of rollers.

Yarn Properties: The yarn count was 55 Tex and the tenacity was 5.5 gm/Tex with a Coefficient of Variation of Strength of 9.8%. The mean extension to break was 13%.

The number of turns of plied twist in each half cycle of plied twist in each intermediate yarn was 42 and the number of turns of plied twist in each half cycle of plied twist in the final yarn was 27.

This yarn was suitable for use as a warp yarn in weaving.

EXAMPLE 2

Material - As in Example 1.

Method : The yarn was prepared in the same manner as in Example 1 but with 1% colloidal silica added to the wool.

Yarn Properties : The yarn count was 55 Tex and the tenacity was 8.0 gm/Tex with a Coefficient of Variation of Strength of 9.6%.

The mean extension to break was 29%.

The number of turns of plied twist in each half cycle of plied twist in each intermediate yarn was 39 and the number of turns of plied twist in each half cycle of plied twist in the final yarn was 29.

This yarn was suitable for use as a warp yarn in weaving.

EXAMPLE 3

Material - Noble combing wool of 23 microns average fibre diameter

1 Tex nylon filament -

Method: The twisting was accomplished with the arrangement shown in Figure 7, two all wool strands being twisted by the first pair of twisting rollers and then converged to form an intermediate yarn. This intermediate yarn and the 1 Tex nylon filament were twisted by the second set of twisting rollers and converged to form the resultant three-strand yarn.

The two roller units each had a stroke of 3 inches and a twist cycle length of 22 cms. and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway between the twist change-over points in the individual strands due to the first set of rollers.

Yarn Properties.: The yarn count was 55 Tex and the tenacity was 4.8 gm/Tex with a Coefficient of Variation of Strength of 16%. The mean extension to break was 14% and the yarn was 98% wool and 2% nylon.

The number of turns of plied twist in each half cycle of plied twist in the intermediate yarn was 39 and the number of turns of plied twist in each half cycle of twist in the final yarn due to the second pair of rollers was 29.

This yarn was suitable for use as a warp yarn in weaving.

EXAMPLE 4

Material - Noble combing wool of 23 microns average fibre diameter

1 Tex nylon filament.

Method : The twisting was accomplished with the arrangement shown in Figure 6 with one 53 Tex wool strand being self-twisted with one 1 Tex nylon filament and the resultant

thread being self-twisted at the second stage with a second 1 Tex nylon filament.

The roller units each had a 3 inch stroke and 22 cms. cycle length and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway between the twist change-over points in the individual strands due to the first set of rollers.

Yarn Properties : The yarn count was 55 Tex and its tenacity was 6.0 gm/Tex with a Coefficient of Variation of Strength of 13%.

The mean extension to break was 12% and the yarn was 96½% wool and 3½% nylon.

This yarn was suitable for use as a warp yarn in weaving.

EXAMPLE 5

Material - Noble combing wool of 23 microns average fibre diameter

2 Tex multi-filament (7 fil) nylon yarn.

Method : The twisting was accomplished with the arrangement shown in Figure 7. Two 26.5 Tex all wool strands were twisted in the first pair of twisting rollers and converged to form an intermediate yarn. This yarn and the 2 Tex multi-filament (7 fil) were passed through the second set of twisting rollers and were converged to form the resultant yarn.

The roller units each had a 3-inch stroke and 22 cms. cycle length and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly

midway between the twist change-over points in the individual strands due to the first set of rollers.

Yarn Properties : The yarn count was 55 Tex and the tenacity was 5.6 gm/Tex with a Coefficient of Variation of Strength of 15%.

The mean extension to break was 15% and the yarn was $96\frac{1}{2}$% wool and $3\frac{1}{2}$% nylon.

This yarn was suitable for use as a warp yarn in weaving.

EXAMPLE 6

Material - Noble combing wool of 23 microns average fibre diameter

2 Tex multi-filament (7 fil) nylon yarn.

Method : The twisting was carried out with the arrangement of Figure 7. One 51 Tex wool strand was self-twisted with one 2 Tex multi-filament (7 fil) nylon yarn by the first set of twisting rollers to form the intermediate yarn and this intermediate yarn was then self-twisted at the second stage with a second 2 Tex multi-filament (7 fil) nylon yarn.

The roller units each had a 3-inch stroke and 22 cms. cycle length and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway between the twist change-over points in the individual strands due to the first set of rollers.

Yarn Properties : The yarn count was 55 Tex and the tenacity was 6.5 gm/Tex with a Coefficient of Variation of Strength of 7.0%.

The mean extension to break was 16% and the yarn

was 92½% wool and 7½% nylon.

This yarn was suitable for use as a warp yarn in weaving.

EXAMPLE 7

Material - Noble combing wool of 23 microns average fibre diameter

1 Tex nylon strand.

Method : The twisting was accomplished with the arrangement of Figure 7, two wool strands being self-twisted together at the first stage to form an intermediate yarn of 29 Tex and this yarn was self-twisted with one 1 Tex nylon strand in the second stage to form the resultant yarn.

The roller units each had a 3-inch stroke and 22 cms. cycle length and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway between the twist change-over points in the individual strands due to the first set of rollers.

Yarn Properties : The yarn count was 30 Tex and the tenacity was 5.0 gm/Tex with a Coefficient of Variation of Strength of 18%.

The mean extension to break was 13% and the yarn was 96½% wool and 3½% nylon.

This 30 Tex yarn of 96½% wool was suitable for use as a warp yarn in weaving.

EXAMPLE 8

Material - Noble combing wool of 23 microns average fibre diameter

1 Tex nylon filament.

Method : The twisting was accomplished with the arrange-

ment of Figure 7. One 28 Tex wool strand was self-twisted with one 1 Tex nylon filament at the first stage to produce an intermediate yarn and the intermediate yarn was self-twisted with one 1 Tex nylon filament at the second stage.

The roller units each had a 3-inch stroke and 22 cms. cycle length and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway between the twist change-over points in the individual strand due to the first set of rollers.

Yarn Properties : The yarn count was 30 Tex and the tenacity was 6.3 gm/Tex with a Coefficient of Variation of Strength of 12%.

The mean extension to break was 14% and the yarn was 93% wool and 7% nylon.

This 30 Tex yarn of 93% wool was suitable for use as a warp yarn in weaving.

EXAMPLE 9

Material - Noble combing wool of 26 microns average fibre diameter

Method : The twisting was achieved with the arrangement shown in Figure 3. Four wool strands were passed through the first pair of twisting rollers and converged to form two intermediate yarns which were then passed through the second set of rollers and then self-twisted together to form a resultant all wool yarn having the structure of Figure 5.

The roller units each had a 3-inch stroke, and 22 cms. cycle length and were phased relative to each other so that in the final yarn the resultant yarn twist due to the second set of rollers had change-over points exactly midway

between the twist change-over points in the individual strands due to the first set of rollers.

The number of turns of plied twist in each half cycle of plied twist in the intermediate yarns was 38 and the number of turns of plied twist per half cycle of plied twist in the final yarn due to the second set of twisting rollers was 20.

Yarn Properties : The yarn count was 90 Tex and the tenacity was 6.3 gm/Tex with a Coefficient of Variation of Strength of 9%.

The mean extension to break was 20%.

This 90 Tex wool yarn was suitable for weaving but not for knitting because of loop distortion.

EXAMPLE 10

Material - Noble combing wool of 26 microns average fibre diameter

Method : Twisting was accomplished with the arrangement of Figure 6. The stroke of the first pair of twisting rollers was 2", and the stroke of the second pair of twisting rollers was 1 inch. The path length of one intermediate yarn between the two pairs of rollers was lengthened so that the twist change-over points of one intermediate yarn fell exactly midway between the twist change-over points of the other intermediate yarn. Phasing between the two pairs of rollers was adjusted so that in the final yarn the resultant yarn twist due to the second set of rollers each of its change-over points exactly midway between a twist change-over point in one intermediate yarn and a twist change-over point in the other intermediate yarn.

Yarn Properties : The yarn count was 90 Tex and the

tenacity was 3.4 gm/Tex with a Coefficient of Variation of Strength of 13%.

The mean extension to break was 9%.

The number of turns of plied twist per half cycle of plied twist in the intermediate yarns due to the first pair of twist rollers was 28 and the number of turns of plied twist per half cycle of plied twist in the final yarn due to the second pair of twist rollers was 8.

It will be seen that the twist levels at both stages in the preparation of this yarn were very much reduced compared with the twist levels in the yarn in Example 9. It was found that this 90 Tex wool yarn was suitable for knitting.

Special properties can be induced into yarns by manipulation of the various parameters effecting the yarn and the basic characteristics of the raw material. We have already shown that when producing a four-strand knitting yarn it is preferred that one of the intermediate yarns should traverse a longer path length than the other intermediate yarn as they pass to the second set of twisting rollers whereas when producing a warp yarn for weaving it is preferred that both path lengths should be the same. It is of course also possible to alter the path length of one of the yarns travelling from the second set of twisting rollers to the final convergence guide in order to "phase" the zones of superimposed twist in the two yarns with respect to one another. It may also be desired to phase the twist distributions in individual strands leaving the first set of twisting rollers with respect to one another before they are converged to form an intermediate yarn.

Furthermore, the twist levels can be varied by altering parameters other than the strokes of the twisting rollers. The twist levels could, for example, be varied by altering the contact pressure between twisting rollers or the lengths between the twisting rollers and the convergence guides. It is to be understood that all of the parameters given are exemplary and may need to be varied considerably if strands of different material are used.

The claims defining the invention are as follows:-

1. A process for forming a stable twisted thread assembly, comprising individually twisting at least one strand of a group of strands so that each twisted strand has repeated along its length successive zones of opposite twist separated by strand twist change-over regions at which there is no twist, converging the strands of the group so that they twist around one another such as to form a stable first thread having successive zones of opposite plying twist separated by plying twist change-over regions at which there is no plying twist, twisting said first thread to superimpose alternately opposite twist in successive zones along its length which latter zones are separated by superimposed twist change-over regions of no superimposed twist, and converging the twisted first thread with a second thread so that the two threads twist around one another to form a stable twisted assembly.

2. A process as claimed in claim 1, in which the second thread, before it is converged with the first thread, is twisted such as to impart alternately opposite twist to successive zones along its length which latter zones are separated by change-over regions of no imparted twist.

3. A process as claimed in claim 2, in which the intensity of the superimposed twist and imparted twist is lower than the intensity of the twist given to each twisted strand of the group when forming the first thread.

4. A process as claimed in claim 2 or claim 3 in which the threads are coverged with zones of like superimposed

and imparted twist in phase and with their change-over regions of no superimposed and no imparted twist coincident.

5. A process as claimed in claim 2 or claim 3 in which the threads are converged with the zones of superimposed twist in the first thread out of phase with like zones imparted twist in the second thread and with their change-over regions of no superimposed twist and no imparted twist spaced from one another.

6. A process as claimed in any one of the preceding claims, in which at least two strands of the group are individually twisted so that each twisted strand has repeated along its length successive zones of opposite twist separated by strand twist change-over regions at which there is no twist before the strands of the group are converged.

7. A process as claimed in claim 6, in which the twisted strands of the group are converged with like twist zones in phase and with their strand twist change-over regions coincident when forming the first thread.

8. A process as claimed in any one of the preceding claims, in which any of said strands and threads is comprised of staple fibres.

9. A process as claimed in any one of the preceding claims, in which any of said strands and threads is a continuous filament.

10. A process as claimed in any one of the preceding claims, in which said second thread is formed by individually twisting at least one strand of a further group of strands so that each twisted strand of a further group has repeated along its length successive zones of

opposite twist separated by strand twist change-over regions at which there is no twist and converging the strands of the further group so that they twist around one another such as to form said second thread as a stable assembly having successive zones of opposite plying twist separated by plying twist change-over regions at which there is no plying twist.

11. A process as claimed in claim 10, in which at least two strands of said further group are individually twisted so that each has repeated along its length successive zones of opposite twist separated by strand twist change-over regions at which there is no twist before the strands of said further group are converged.

12. A process as claimed in claim 11, in which the twisted strands of said further group are converged with like twist zones in phase and with their strand twist change-over regions coincident when forming the second thread.

13. A process as claimed in any one of claims 10 to 12, in which the first and second threads are converged with the zones of strand twist in the first thread in phase with zones of like strand twist in the second thread.

14. A process as claimed in any one of claims 10 to 12, in which the first and second threads are converged with the zones of strand twist in the first thead out of phase with the zones of like strand twist in the second thread.

15. A process as claimed in any one of claims 10 to 14, in which the change-over regions of no imparted twist are displaced from the plying twist change-over regions in the second thread.

16. A process as claimed in any one of the preceding claims, in which the change-over regions of no superimposed twist are displaced from the plying twist change-over regions in the first thread.

17. A yarn comprising a stable twisted thread assembly as formed by a process as claimed in any one of the preceding claims.

18. A twist stable yarn comprising a plurality of threads which are plied about one another in opposite directions in successive yarn zones along the length of the yarn and wherein at least one of the threads is comprised of a plurality of strands which are plied together in alternately opposite directions in successive thread zones along the length of the yarn and which have alternately oppositely directed strand twist in successvie strand zones along the length of the yarn, the strand zones being out of phase with the thread zones and the yarn zones being out of phase with both the strand zones and the thread zones.

19. Apparatus for producing a stable twisted thread assembly, comprising first twisting means to impart alternating zones of opposite strand twist to each strand of a group of strands, first converging means adjacent the first twisting means to converge the first group of strands to form a first thread, second twisting means to superimpose alternating zones of opposite twist upon the first thread and second converging means adjacent the second twisting means to converge the first thread with a second thread.

20. Apparatus for producing a stable twisted thread assembly, comprising first twisting means simultaneously to

impart alternating zones of opposite strand twist to each strand of a first and second group of strands, first converging means adjacent the first twisting means to converge the first group of strands to form a first thread and also to converge the second group of strands to form a second thread, second twisting means simultaneously to superimpose alternating zones of opposite twist individually upon the first and second threads and second converging means adjacent the second twisting means to converge the first and second threads.

21. Apparatus as claimed in claim 19 or claim 20, in which the first twisting means and the second twisting means each comprises a pair of oppositely rotated transversely reciprocating twisting rollers.

22. Apparatus as claimed in claim 21, in which the two pairs of rollers are reciprocated by common drive means such that the reciprocating movements of the two pairs bear a constant phase relationship with one another.

23. Apparatus as claimed in claim 21 or claim 22, in which the distance between the two pairs of twisting rollers is at least as great as the length of the zones of twist imparted by the first pair of twisting rollers.

24. Apparatus as claimed in claim 23, in which the distance between the two pairs of twisting rollers is in range 12 to 40 centimetres.

25. Apparatus as claimed in any one of claims 21 to 24, in which the strokes of the two pairs of twisting rollers are equal.

26. Apparatus as claimed in any one of claims 21 to 25, in which the stroke of each pair of twisting rollers falls within the range 2 to 7 inches.

27. A process for forming a stable twisted thread assembly, substantially as hereinbefore described with reference to Figures 3 to 5 of the accompanying drawings.

28. A process for forming a stable twisted thread assembly, substantially as hereinbefore described with reference to Figure 6 or with reference to Figure 7 of the accompanying drawings.

29. Apparatus for producing a stable twisted thread assembly, substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

Dated this 10th day of August 1970

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
By its Patent Attorneys
DAVIES & COLLISON

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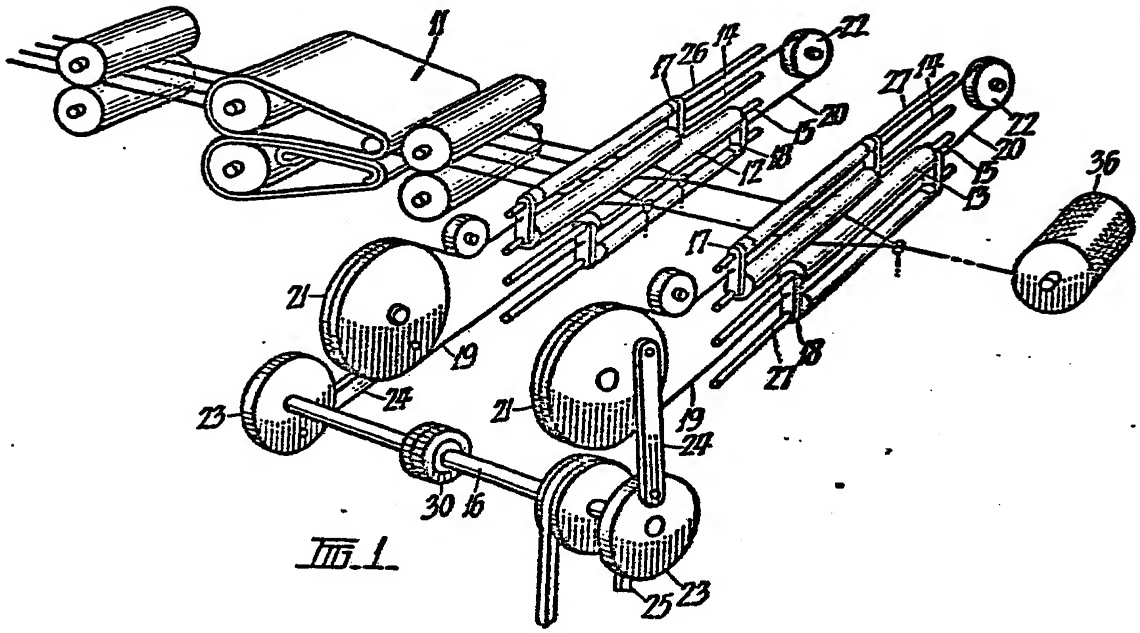

FIG. 1

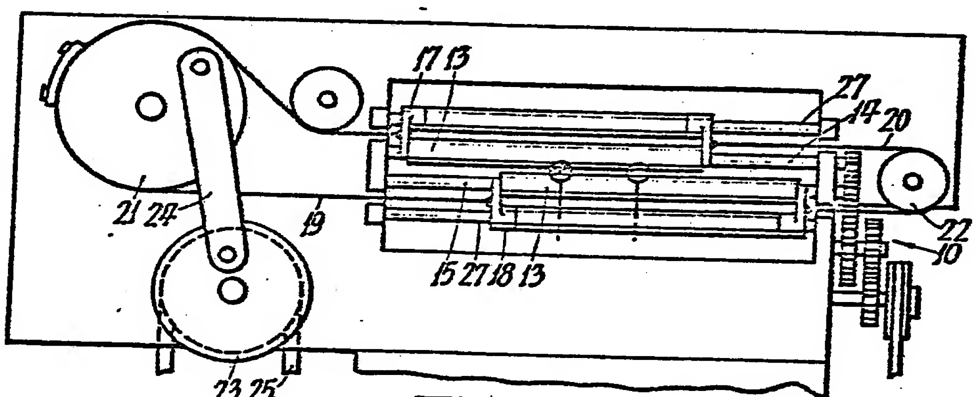

FIG. 2

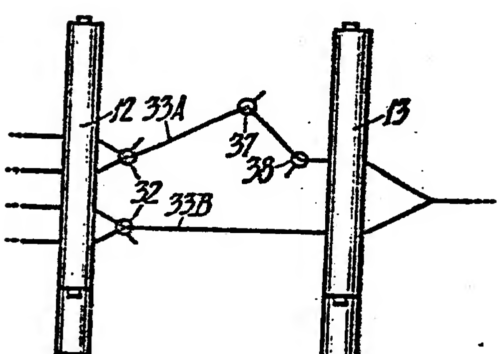

FIG. 6

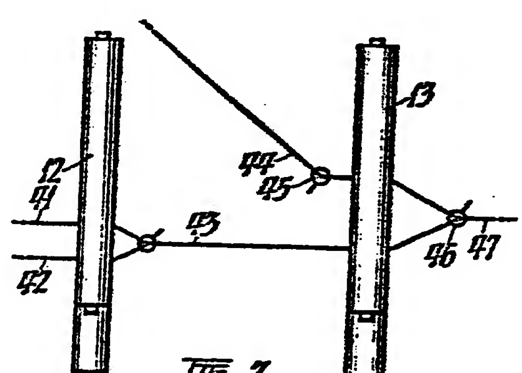

FIG. 7

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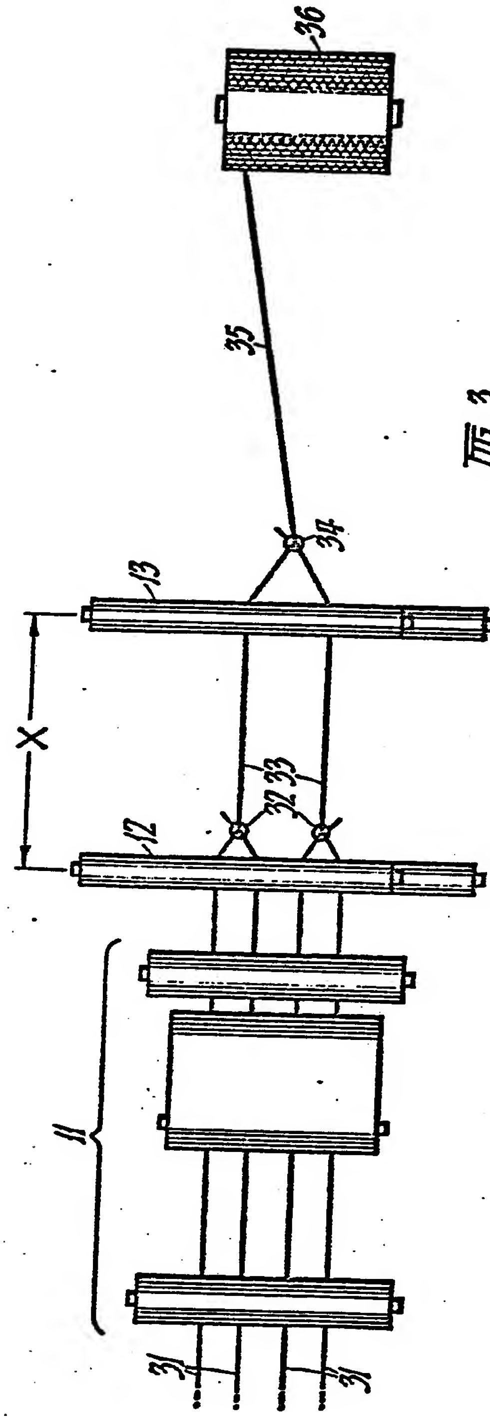

Fig. 3.

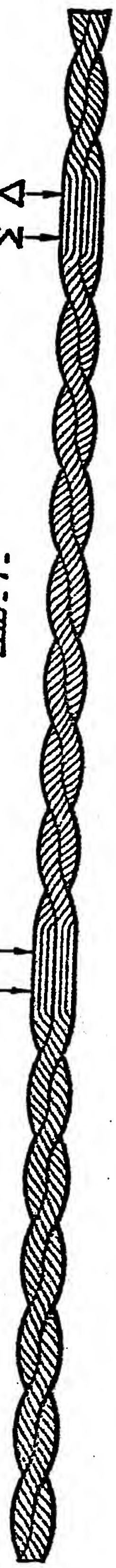

Fig. 4.

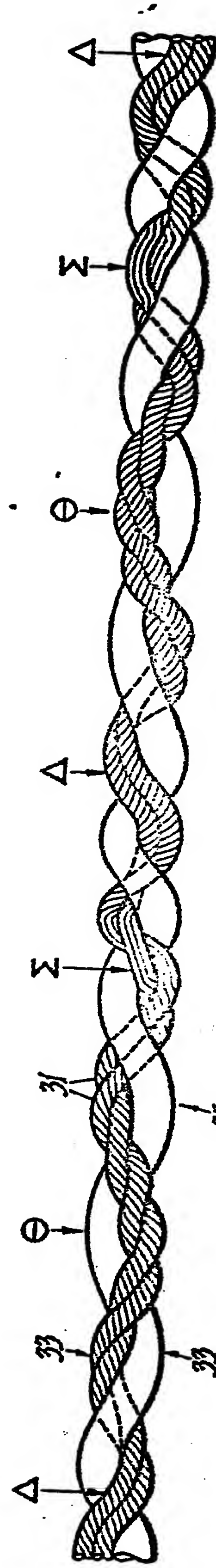

Fig. 5.